Framework Integration to Support the Development of Future Internet Enterprise Systems

Mihnea Alexandru Moisescu[1], Ioan Stefan Sacala[2]

University Politehnica of Bucharest, Romania /Faculty of Automatic Control and Computers Science
313 Splaiul Independentei Street, Sector 6, Bucharest, Romania, 060042

[*1]mamihnea@gmail.com; [2]sacalaioan@yahoo.com

Abstract

Information, nowadays a commodity, keeps the knowledge representation and management within the framework of knowledge driven economy towards sustainability of next generation of Future Internet Enterprise Systems (FInES). However, the Information Society requires new holistic approaches to perform acquisition, collection, processing, deposition, distribution of data, information and knowledge according to a coherent choreography procedure within geographically dispersed enterprises. The development of new Internet related concepts oriented towards providing positive benefits for economy has been included in a broad concept of "Future Internet Based Enterprise Systems". In this context, the authors propose a framework for development of FInES.

Keywords

Future Internet Enterprise Systems; Digital Business EcoSystems; Interoperability

Introduction

In order to extend the boundaries of collaboration, interoperability and knowledge exchange with other enterprises, research institutes and academic research groups, new tools and technologies must be taken into consideration. Based on the authors expertise within manufacturing systems, knowledge based systems, control systems, enterprise architecture and future internet systems, in order to sustain the paradigm shift, a new modelling framework for Future Internet Enterprise Systems (FInES) is presented. In this way, intelligence could be obtained from enterprises through the existing information, detained by each component, contextualized in a given situation.

Paradigm Shifts towards Future Internet Enterprise Systems

Different existing manufacturing paradigms like Concurrent Engineering, Virtual Organizations (Camarinha-Matos, 2007), Intelligent Manufacturing Systems and Networked Enterprises (Moisescu, Sacala, 2012), have incorporated collaborative structures and provided complex architectures based on specific communication channels and infrastructure in order to ensure efficient use of models and processes.

The paradigm shifts that one could notice in computer science [e.g. Service Oriented Architecture, Enterprise Bus, Interoperability Service Utility] are great challenges for our daily R&D activities. (Goncalves, 2010)

Collaborative Networked Organizations (CNO) represent one of the most relevant organizational paradigms in industry and services and a new dynamic world, based on cooperation, competitiveness, agility and adaptability. They are complex production structures–scaling from machine tools, robots, conveyors, to knowledge networks, including humans – and that should be designed as autonomous but collaborative entities. (Camarinha-Matos, 2007)

Intelligent Manufacturing Systems (IMS) can be viewed as large pools of human and software agents, with different levels of expertise, which have to act together, in variable configurations of temporary communities in order to react to dynamically changing objectives. (Moisescu, Sacala, 2012)

A short, focused, version of the roadmap concerning the enterprise system science evolution during the last half century is presented in Figure 1.

The current global dynamic market convergence introduces the necessity of a new methodology to sustain the new 4^{th} shift.

In this context, the paradigm shift towards Future

Internet Enterprise Systems involves four complex features:

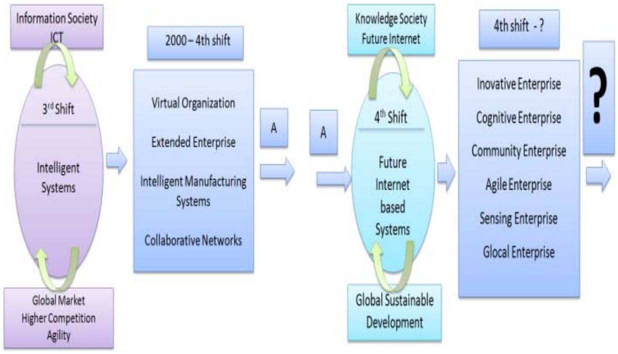

FIG. 1 SUCCESSIVE PARADIGM SHIFTS THAT INFLUENCED ENTERPRISE SYSTEMS

1. Need of advanced mathematical support, with emphasis on discrete algebra and complexity theory.

2. Five Dimensions of holistic modeling support: functional, structural, behavioral, componential and architectural.

3. The effective use of the Internet of Future (Internet of Things, Internet of Services, Internet of Knowledge, Internet by and for People) make technology has the ability to conceptually design a Complex Adaptive System of Systems based on interoperability, availability, scalability and traceability.

4. Intelligent systems (e.g. multi-agent/hybrid agent to enhance computational facilities).

Considering the development and the structure of Intelligent Manufacturing, it becomes obvious that it corresponds to the definitions of Complex Adaptive Systems that include:

***reactive** units, i.e., units capable of exhibiting systematically different attributes in reaction to changed environmental conditions.*

***goal-directed** units, i.e., units that are reactive and direct at least some of their reactions towards the achievement of built-in (or evolved) goals.*

***planner** units, i.e., units that are goal-directed and attempt to exert some degree of control over their environment to facilitate achievement of these goals.*

*FInES community has already provided a roadmap, constantly revised and updated, during the last decade. (FInES resear*ch roadmap, 2012) (Sacala, Moisescu, 2012)

According to prof. Michele Missikoff, the old 4 tiers during Aristoteles time (Philosophy, Science, Engineering, Technology) have a new interesting approach: Philosophy is replaced by meta-modelling within System Paradigm. (Missikoff, 2009)

In figure 2 the basic Future Internet Enterprise Systems Architecture is presented.

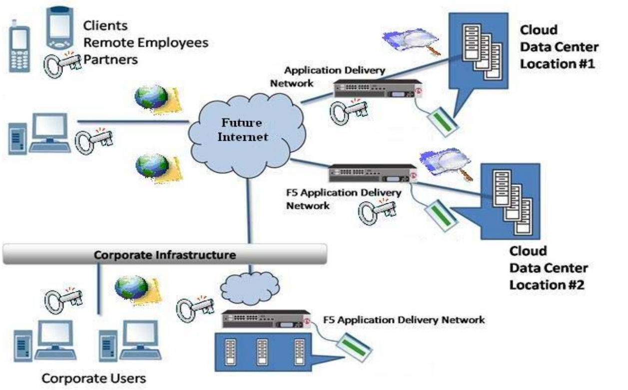

FIG. 2 THE FINES ARCHITECTURE

The complexity generated by the number of dimensions that will emerge from Future Internet Enterprise Systems will shift the interoperability analysis towards the tools offered by the System of Systems paradigm.

In this context the development of new Internet related concepts and technologies oriented towards providing positive benefits for individuals, society, economy, culture and environment has been included in a broad concept o Future Internet Systems. The development of Future Internet Enterprise Systems (FInES) has been oriented towards enabling enterprises and SMEs to have access to the full potential of Future Internet technologies through ICT.

Key Requirements towards the Development of a Methodology for Future Internet Enterprise System of Sytems

The development of new concepts in the field of enterprise collaboration (Collaborative Networks and Digital Business Ecosystem), the intensive use of Service Oriented Architectures based on the existing infrastructure provided by Cloud Computing technologies and the continuous demand for communication and collaboration are pushing the existing internet technologies to the highest limit . (Dumitrache, 2009), (Stricker, 2010), (Kaposi, 2001)

In the existing turbulent, global market, the FP6 IST project "Virtual Organization Roadmap" provided the first statement regarding the enterprise evolution, that is "Every sustainable enterprise should

reach, beyond 2012, the capability of networking in Virtual Organizations".

The concept of Digital Business EcoSystem (DBES) initiative responds ideally to this challenge of creating ICT instruments together with collaborative practices and paradigms that support economic growth and include all the societal and economic actors in the process. It has been commonly recognized as a new frontier for Research and Technology Development (RTD) in the knowledge-based economy.

Small and Medium Enterprises (SMEs) and local clusters are now competing in a global and dynamic market where they need more interrelations, more specialized resources, more research and innovation as well as access to global value chains and knowledge. The research driven within the DBE initiative supports all these necessities by offering an open infrastructure that combines

- human capital,
- knowledge and practices,
- technical infrastructure,
- business and financial conditions

all modeled within the European industrial policy agenda. (Dumitrache, 2009)

As one of Internet's expanding directions is to become an universal business environment, the business values associated may refer to (Moisescu, Sacala, 2012):

- Revenue and profit.
- Reputation and level of trust.
- Resource planning towards efficient use.
- Green manufacturing.
- Enterprise social networking.
- Business partners collaboration.
- Customer relationships.
- Tacit and implicit Enterprise Knowledge Management.
- Business transparency and corporate governance.

In order to achieve these characteristics, the following dimensions of an enterprise must be taken into consideration: flexibility, adaptability, collaboration, innovation, knowledge management, openness and so on. The quality of an enterprise is another very important aspect that has been greatly emphasized, in the last few years. New concerns like social and environmental impact, cultural diversity and ethical issues, have to be taken into consideration in order to obtain the Total Quality Management standards.

In this way, Quality of Being (QoB) is a new concept that integrates the quality aspects with the existing operations within an enterprise: products, strategies, human resources, client relationships, resource planning, green manufacturing, social responsibility, community vs. global impact.

Based on these aspects, the Internet Enterprise Resource (FInER) concept is used in order to describe the virtualization of enterprise entities which allow identification of the existing processes and communication channels, computational power and storage. The FInER concept is used as a base for the FInES evolution by creating different networks of FInERs. Internet of Knowledge plays an important role in establishing these networks, in order to sustain the FInES evolution.

The existing knowledge management tools and technologies will have to be represented in a coherent and consistent way, using flows of knowledge from distributed, geographically dispersed FInER collections, accessible through different communication channels and internet infrastructure. Ontologies and semantic web play an important role in representing meta-knowledge infrastructure.

The research objectives as stated by the FInES EU Cluster in relationship with Future Internet technologies and QoB can be identified as:

- Inventive Enterprise.
- Cloud Enterprise.
- Cognizant Enterprise.
- Community-oriented Enterprise.
- Green Enterprise.
- Global Enterprise.

The existing technological paradigms used as a basis to sustain the future research, regarding Future Internet Enterprise Systems, are: Applications with reactive and proactive behaviour, Infrastructure as a Service, Platform as a Service, Software as a Service, Interoperability Service Utility (ISU), Cloud Computing, Cyber Physical Systems, Knowledge

Extraction and Representation, Semantic Modeling, Multi-Agent Systems, Federated-Open-Trusted Platforms, Automated Service Discovery and Configuration, Automated Service Composability, Quality of Services, Syntactic and Semantic Interoperability.

Since nowadays agility is the key in satisfying the customer's needs, the enterprises must consider innovation as their leading means to survive on the market. Every new technology brings advantages as well as disadvantages. To maintain and increase their business profitability, enterprises should employ these new technologies carefully taking into account different vital aspects (security, interoperability, affordability, reliability) according to their domain of activity: ecommerce, eHealth, eLearning.

In this context, we propose a methodology as described in figure 3, based on the tires described below, and the Observe – Orient- Decide-Act paradigm principles.

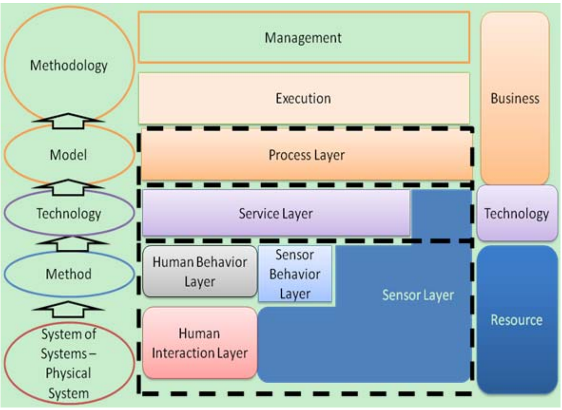

FIG. 3 TOP-DOWN HOLISTIC METHODOLOGY

The five tires involve (Stanescu, 2007):

- Systemic Paradigms
- Modeling Framework
- Methodology to allow for a synthetic approach
- Methods and techniques
- Information System Architecture

Our basis for the analysis has three key elements: decision making, integration and behaviors. These three elements are completed with the next considerations:

Plan and Organize

All the processes are taken into account, but divided into three levels: strategy, management and communications.

Acquire and Implement; Deliver and Support.

The contribution to the model is based on considering all the existing processes and their relations from the point of view of one system, in order to provide value for enterprises.

Monitor and Evaluate

All the processes are taken into consideration.

Based on this model, the fundamental system requirements are: Adaptability, Autonomy, Self-organizing, Decomposability, Decision Making, Viability, Manageability. Taking into consideration these characteristics, the system, at the contextual level, must include the following features: Scalability, Portability, Traceability, Interoperability, Complexity, and Availability.

Framework Integration to Support the Development of Future Internet Enterprise Systems

The development of new Internet related technologies (Internet of Things, Internet of Services, Internet of Knowledge, Internet by and for People) oriented towards increasing the benefits of individuals, economy, society, culture and environment has been included under the umbrella of Future Internet Enterprise Systems.

Integration of these concepts for enterprise collaboration and interoperability based on the existing infrastructure provided by Cloud Computing technologies and the permanent demand for communication and collaboration is pushing to the limits of the current existing solutions.

In this context, a new concept has been introduced: Internet Enterprise Resource (FInER) as a method to virtualize enterprise entities, no matter whether they are tangible or intangible, simple or complex. These entities allow for identification of the existing processes and communication channels, computational power and storage. The FInER concept is used as a base for the FInES evolution by creating different networks of FInERs. Internet of Knowledge plays an important role in establishing these networks, in order to sustain the FInES evolution within the enterprise business process re-engineering.

The existing knowledge management tools and knowledge repositories will be replaced by different kinds of knowledge flows, from distributed FInER collections accessible via internet infrastructure with

the help of different linked ontologies.

Quality of Being (QoB) integrates the quality aspects with the existing operations within an enterprise: products, strategies, human resources, client relationships, resource planning, green manufacturing, social responsibility, community vs. global impact. A set of QoB predictions has been identified in the FInES roadmap, in order to integrate the Future Internet technologies (FInES research roadmap, 2012):

- Inventive Enteprise
- Humanistic Enterprise
- Cognitive Enterprise
- Community-oriented Enterprise
- Agile Enterprise
- Glocal Enterprise
- Sensing Enterprise

Missikoff (2009) stated that, for integration of new trends, the reference architecture must be divided into 3 distinct layers: Functional, Logical and Technical. Likewise, the existing methods, depending on the context, of the Service-based Systems integration has to be considered.

An important aspect of FInES is the integration of the new approaches to the Future Internet: Internet of Service, Internet of Things, 3D and Media Internet, Internet of Knowledge, Internet of Human.

In the context of economic globalization, enterprises had to be adaptive in order to operate at an international level. In this way, the existing methods used for sourcing, production, finance and technologies had to be re-shaped. Thus, with the economy development, new business scenarios appeared, with new stakeholders. Nevertheless, in different business environments where enterprises are not transparent or agile, globalization is accepted with hardness in different countries. As globalization has been spreading all over the world, a number of corrections in the business process are the best solution to enterprises.

One feasible solution is provided by the possibility of taking into account the two apparently opposite dimensions (local and global), merging into a a new form referred to as "glocal". A glocal enterprise will be able to see, understand, think and decide at a global level, taking into consideration the local level at which it operates and the geographical, political, economical, social and cultural aspects. In order to be glocal, enterprises must be flexible, easy to adapt, capable to introduce new products and services, according to the specific needs of a geographic area.

In figure 4, a framework is presented to model data assigned to a real object. The framework adds to the existing data with new data that allows for virtualization of object information, depending on its behaviour or functionality and the relations with other objects.

As the object properties and description have already been implemented within the Internet of Things (RFID tags), this research is focused on representing objects description in order to define and implement object behaviour. A problem is to find appropriate tools to describe this data.

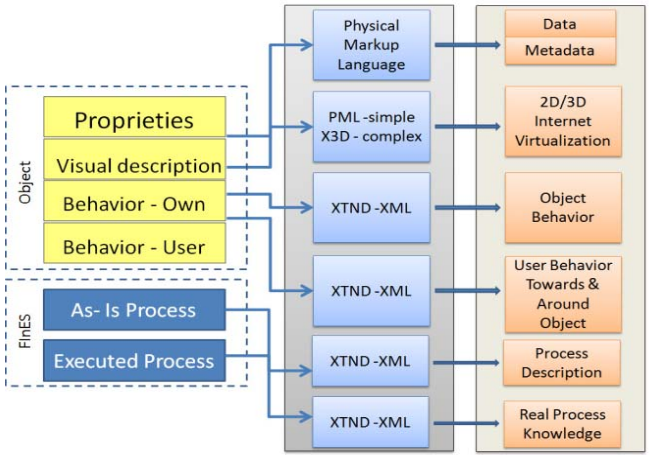

FIG. 4 REPRESENTATION OF FINER OBJECT BLOCKS

The integration of objects within the "Internet of Things" (Moisescu, Sacala, 2010) offers great perspectives, but it is not easy to be implemented at this point, taking into consideration the following aspects:

- different or no interoperability standards
- different service descriptions and capability declaration
- different radio interfaces and media access
- different resources management
- different encryption
- different publication and subscription of devices

In figure 5, a brief representation of the three dimensions is presented that must be taken into consideration, as well as the main concepts.

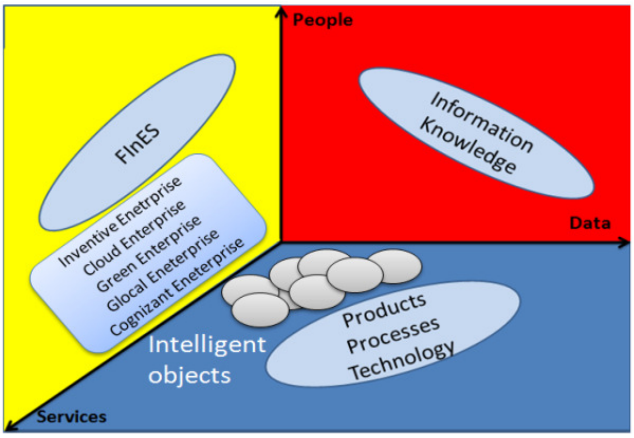

FIG. 5 DIMENSIONS OF ENTERPRISE SYSTEMS

As it has been well known that a suitable and intensively used for data transfer is Extended Markup Language. As PML (Physical Markup Language based on XML) has been widely adopted by the users of EPC (Electronic Product Code) standard, PML will be in use for the description of object properties within the frameworkas well as object shapes and colors, but the description of object properties will be limited in general. For object shapes and colors description, a more appropriate tool X3D is employed which is considered as the future of 3D web communication, and used for communication between applications, across distributed networks and web services. In order to describe the behaviour of the object and the relations with other objects, XTND-XML Transition Network Definition Language will be utilized. In order to model behaviours, the easiest way is to use transition networks that are used to describe a set of states and possible transitions.

The development of different methods used to transform simple objects, as they are seen within enterprise business processes, into intelligent objects, is considered a real benefit for enterprise planification. Thus, the first step is to be able to identify the existing objects, depending on the type, then distinguish it from other objects and environment, followed by the classification according to need and the establishment of inter-object relationships.

The progress in regard to RFID technologies has boosted the capability of object identification and allowed for the development of new methods for identification. These technologies are based on the existence of a remote databes for information extraction. With the development of more powerful data storage devices in the last years, data has been stored on the tag attached to the object and accessed whenever or wherever it is necessary.

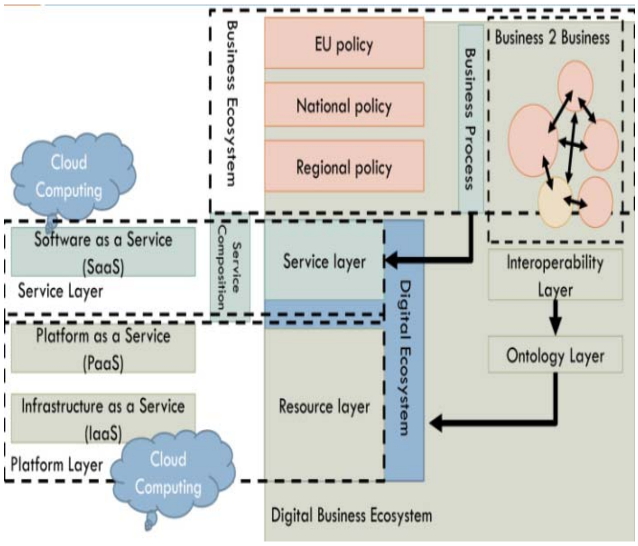

FIG. 6 INTEGRATING FINES WITHIN DIGITAL BUSINESS ECOSYSTEM

In figure 6, based on the existing technologies, the authors present different methods, depending on the type of business involved in a geographical area, in order to integrate distinct enterprise systems within a Digital Business Ecosystem. Thus, an interoperability layer as well as an ontology layer is presented.

Interoperability framework includes:

- organizational interoperability focused on business process interoperability and information architectures
- Semantic interoperability in order to establish a common meaning of the exchanged data, process models or different procedures.
- Syntactic interoperability used for communication and exchanging data based on different communication protocols and data formats.

Ontology level provides used at the semantic level takes the role in description on the semantics of the modelling language contructs, as well as the model instances. Thus, ontologies are used for explanation of semantics of activites and the description on the semantics of a specific activity.

The second step is to integrate these objects within the enterprise systems. Thus, the information attached to the tag should be divided into the following categories:

- Object properties
- Object functionality (object behavior)
- Description of planned processes
- Description of the actual processes

This classification allows for creation of a map of the processes that the object will be subjected to, ensuring a better integration with the services used within Enterprise Systems. In this way, any enterprise system will be able to read the process map and take the right decision.

As the actual process may vary, as well as the planned processes of the object, a record to register the changes can be defined. In this way, feedback is provided regarding the sub-processes and activities involved. This information can be further processed and transmitted in order to be integrated within an Enterprise Management System and produce valuable knowledge that can be used at any time. Thus, depending on the existing records, the decision can be taken based on the corresponding scenario, as well as the actual and planned processes.

In figure 7, the process of integration of intelligent objects as FINER within enterprise systems is presented.

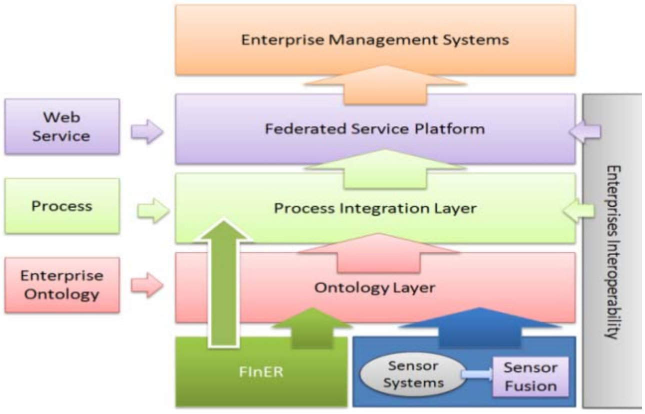

FIG. 7 OBJECTS REPRESENTED AS FINER WITHIN THE FINES KNOWLEDGE MANAGEMENT SYSTEM

Conclusions

As an Enterprise System could facilitate the ability to obtain the necessary information in management and decision making, it can help to make correct and timely decisions with the characteristics of integration, sharing of various kinds of resources and improvement on the efficiency of enterprises management.

The concepts proposed within the Internet of Things, paradigm are becoming a reality, due to the research efforts leading towards the development of new devices and services.

Efficient interoperability, both syntactic and semantic, at all levels, is a basic requirement for Enterprise System Integration within Collaborative Competitive Enterprises.

REFERENCES

Camarinha-Matos, L., Afsarmanesh, H., Novais, P., Analide, C. "Establishing the Foundation of Collaborative Networks", PROVE Virtual Enterprise 2007, Springer Verlag ISBN, 978-0-387-73797-3.

Dumitrache, I., Stanescu, A.M., Caramihai, S.I., Voinescu, M., Moisescu, M.A., Sacala, I.S., "Knowledge Management Based Supply Chain In Learning Organization", In: 13th IFAC Symposium on Information Control Problems in Manufacturing (Incom 2009), 3-5 Jun 2009, Moscow, Russian federation

FInES Research Roadmap Task Force, "Future Internet Enterprise Systems (FInES) Cluster, Research Roadmap", Version 2.0, March 2012, http://cordis.europa.eu/fp7/ict/enet/.

Goncalves R., Sarraipa J. and Steiger-Garcao A., " Semantic harmonization for seamless networked supply chain planning in the future of internet", IFIP International Conference Network of the Future, IFIP AICT 326, pp. 78--89. IFIP International Federation for Information Processing, 2010, Australia. (IFIP)

Kaposi, A., Myers, M., "Systems for all", Imperial College Press, Singapore, 2001.

Missikoff, M.;(2009): "Let's Semanticise the World!!...or not?" ICEIS (1) pp.17-24, 2009

Moisescu Mihnea Alexandru, Sacala Ioan Stefan, Stanescu Aurelian Mihai, "Towards the development of Internet of Things oriented Intelligent Systems", UPB Scientific Bulletin, Series C, Vol. 72, Iss. 4, 2010, ISSN 1454-234x

Moisescu M. A., Sacala I. S., Stanescu A.M., Serbanescu C., "Towards Integration of Knowledge Extraction from Process Interoperability in Future Internet Enterprise Systems", *Proceedings* of IFAC INCOM 2012, Information Control Problems in Manufacturing, ISBN: 978-3-902661-98-2, 2012.

Sacala Ioan Stefan, Moisescu Mihnea Alexandru, Mihai Sacala, "Towards the development of Future Internet Enterprise Systems", Romanian Statistical Review, Nr.2, Volume 60, pp. 472-474, ISSN 1018-046X, 2012

Stanescu A.M., Dumitrache I., Pouly M., Caramihai S.

I., Moisescu, M., “Towards a General Systems Theory approach to design the future of Concurrent Engineering Science”, In Geilson Loureiro and Richard Curran (ed.) Complex Systems Concurrent Engineering Collaboration Technology Innovation and Sustainability, pp 3-10, Springer Verlag, 2007.

Stricker V., Lauenroth K., Corte P., Gittler F., De Panfilis S., Pohl K., “ Creating a Reference Architecture for Service-Based Systems-A Pattern-Based Approach”, In Georgios Tselentis et all (eds.) Towards the Future Internet, Emerging Trends from European Research. 161-173, IOS Press, 2010